Appendix 1. User manual for the Salmon ISEMP watershed model.

The VFT Model

(Virtual Fish Transmorgrifier)

Quantitative Consultants, Inc.

1.0

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Theory of Operation

The VFT model was developed for the Salmon Integrated Status and Effectiveness Monitoring Project (ISEMP) by Quantitative Consultants, Inc. to provide an analytical framework and prescribe data requirements for habitat action effectiveness monitoring and population status and trends monitoring in target watersheds. The model uses a general population dynamics model to describe how empirical data on habitat features and population attributes could be used independently and/or in concert with GIS (or remote sensing data such as satellite imagery) to describe the quantity and quality of available habitat and the influence of those factors on the growth rate of a population or group of populations of interest. The user can model population response to habitat changes using either a deterministic relationship or by simulating the influence of uncertainty on the parameter(s) of interest. The model van also be used to evaluate the impact of artificial propagation on population growth rate given information on the productivity of naturally spawning hatchery origin adults.

The VFT is a watershed scale model that evaluates productivity and carrying capacity by life-cycle stage as a function of habitat availability and quality, and then simulates expected life-stage specific benefits from increased habitat availability or quality.

Model Overview

The model is an adapted Beverton-Holt model spawner recruit model (Beverton and Holt 1957) applied to Chinook salmon (Hilborn and Walters 1992). The basic structure of the model is the traditional Beverton-Holt population dynamics model:

$$R_{t+1} = \frac{aS_t}{b + S_t}$$

where R_{t+1} is the recruits in time $t+1$, S_t is the spawners in time t, and a and b are parameters of the model. Harvest rate (u_t) is incorporated as follows:

$$N_{i+1,t+1} = \frac{aN_{i,t}}{b + N_{i,t}}\left(1 - u_{t+1}\right)$$

where $N_{i,t}$ is the number of individuals in stage i at time t. In this case, the t refers to the generation of salmon, ignoring the fact that many salmon return to spawn at different ages. Mousalli and Hilborn (1986) used a sequence of Beverton-Holt models to represent the different life history stages of salmon and Sharma et al. (2005) further modified the above models to directly relate the model parameters to habitat quality and quantity. The approach is an extension of Moussali and Hilborn's model (1986) shown below:

$$N_{i+1,t+1} = \frac{N_{i,t}}{\frac{1}{p_{i,t}} + \frac{1}{c_{i,t}} N_{i,t}}$$

where $N_{i,t}$ is the number of individuals alive at the beginning of life history stage i at time t, p_i is the “productivity” at stage i (the maximum survival rate from stage i to $i+1$) and c_i is the “capacity” (the maximum number of individuals that will survive from stage i at time t to stage $i+1$ at time $t+1$).

Productivity (p) is calcuated as

$$p_{i,t} = Sr_i \times \frac{\sum_{q=1}^{n} E_{i,q} \times L_{q,k,t}}{\sum_{q=1}^{n} L_{q,k,t}}$$

where
p_i is the density independent productivity for stage i dependent on the relative importance/relationship between productivity and land use in that stream,
$L_{g,k,t}$ is the land-use type (q) in watershed (k)during a specific time period (t),
$E_{i,q}$ is a scalar showing the importance of land-use type (q) for overall productivity, and
Sr_i = average maximum survival rate from one stage to the next in the fresh-water life history of the species given average conditions compared to a baseline in the best possible habitat suited for their survival.
To estimate the amount of a habitat type j in watershed k at time t, $(H_{k,j})_t$, we begin with the area (m^2) of stream in watershed k with species appropriate gradient (A_k) and the percent of area in watershed k in land use class q at time t, $(L_{qk})_t$. Note that the sum of the $L_{q,k}$ is equal to A. The percent of stream habitat types j (e.g. pools, cascades, glides, riffles, rapids/runs and other) found in land use class q, $(M_{j,q})$. The amount of habitat type j in watershed k at time t $(H_{k,j})_t$ via the equation:

$$H_{k,j,t} = A_k \times \sum_{q=1}^{n} \left[M_{j,q} * L_{q,k,t} \right]$$

Stage-specific carrying capacities $(c_{k,i})_t$ for watershed k in life history type i at time t is then calculated as:

$$c_{k,i,t} = \sum_{j=1}^{n} H_{k,j,t} * D_{j,i}$$

where $D_{i,j}$ is the number of individuals in each life-history stage, i (eggs, fry, parr and pre-smolts) that could be maintained per square-meter of each habitat type j.
The general form of the VFT model is rewritten in terms of the land use based productivity and capacity estimates, by freshwater life history stage for the species being modeled in watershed k as:

$$N_{k,i,t+1} = \frac{N_{k,i,t}}{\dfrac{1}{Sr_i * \dfrac{\sum_{q=1}^{n} E_{i,q} * L_{q,k,t}}{\sum_{q=1}^{n} L_{q,k,t}}} + \dfrac{1}{A_k * \sum_{j=1}^{n}\left[\left[\sum_{q=1}^{n} M_{j,q} * L_{q,k,t}\right] * D_{j,i}\right]} N_{k,i,t}}$$

For the ocean life stages the model is further modified to allow for yearly ocean suvival by age (o_a) and maturity rate by age (M_a). For clarity of description, subscripts are changed to age (*a*) for time periods.

$$N_{i,a+1} = \frac{N_{i,a}\left(1 - M_a\right)}{\dfrac{1}{o_{a+1}} + \left(\dfrac{1}{c_{i,a}} N_{i,a}(1 - M_a)\right)}$$

Harvest can be incorporated as in the orignial Mousalli and Hilborn (1986) model by applying at the approapriate life-stage or time period by:

$$N_{i+1,t+1} = \frac{N_{i,t}}{\dfrac{1}{p_{i,t}} + \dfrac{1}{c_{i,t}} N_{i,t}} * (1 - u_{i,t})$$

Hatchery domestication effects are also combined in the VFT by adjusting the productivity of the population by the magnitude and duration of hatchery fish spawning within the populations. From Sharma et al (2005), the average number of hatchery generations (*AHG*) incorporated into the natural population (*W*) is calculated as:

$$AHG_{W,t+1} = \frac{\left(\left(N_{1,t}^{W} * AHG_{W,t}\right) + \left(N_{1,t}^{H} * AHG_{H,t}\right)\right)}{N_{1,t}^{W} + N_{1,t}^{H}}$$

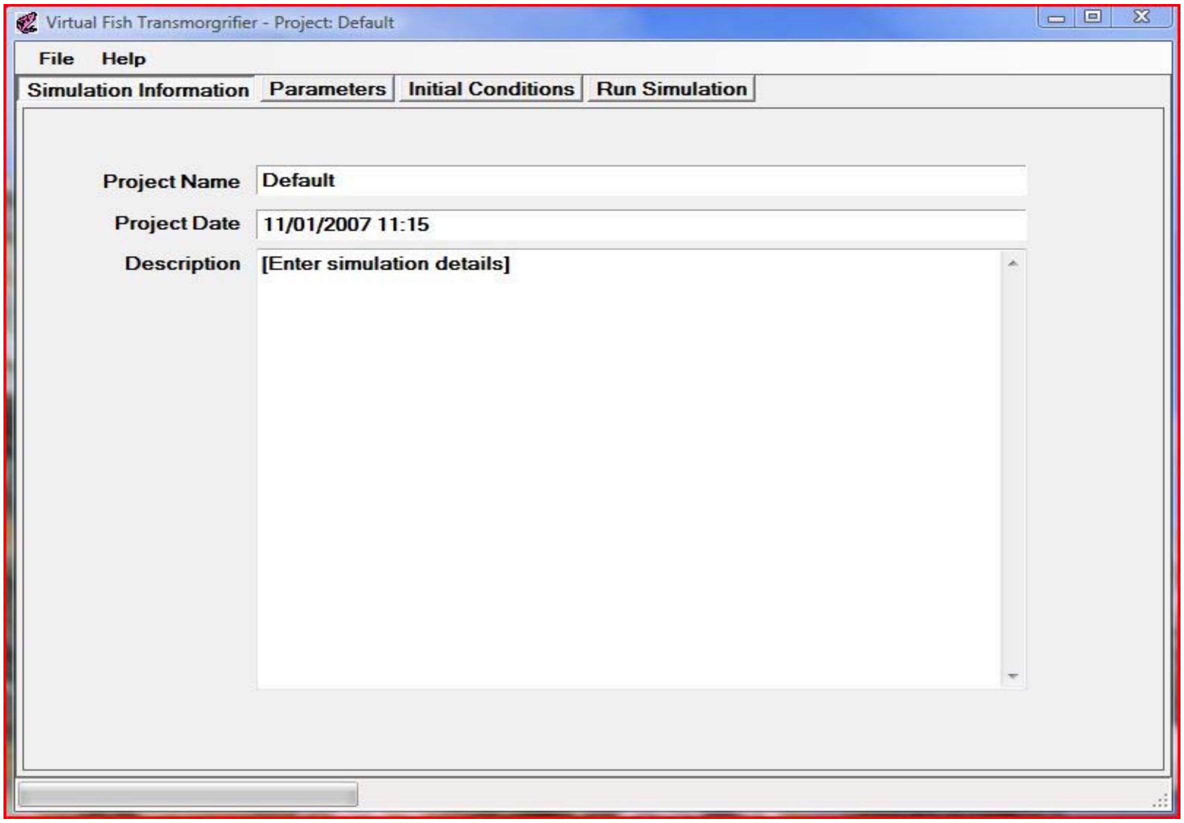
where *AHG* is the average hatchery generation of the natural stock's next cohort at the egg stage based on hatchery strays (N^H) spawning in the wild and the number of natural fish (N^H) spawning in the wild weighted by the domestication factor of each cohort. The stage based survival (*p*) in the VFT model is than adjusted by:

$$p'_{i,t} = p_{i,t} e^{-\theta * (AHG_W)}$$

where theta is the rate at which survival decreases with increasing generations of domestication at a specific life stage.

Simulation Setup

The simulation is driven by several sets of data that can be found in four separate tabs in the Program Interface Screen, that describe the project, habitat of the watershed being simulated, assumptions about productivity and capacity, maturation rates, survival rates, hatchery effects, and initial conditions.



Simulation Information

This is the initial screen where the user enters details on the project that is being simulated for future reference. See Projects and Organizing Data Section for more information.

Project Name

A unique name (up to 255 characters in length – only editable when saving a new project.)

Project Date

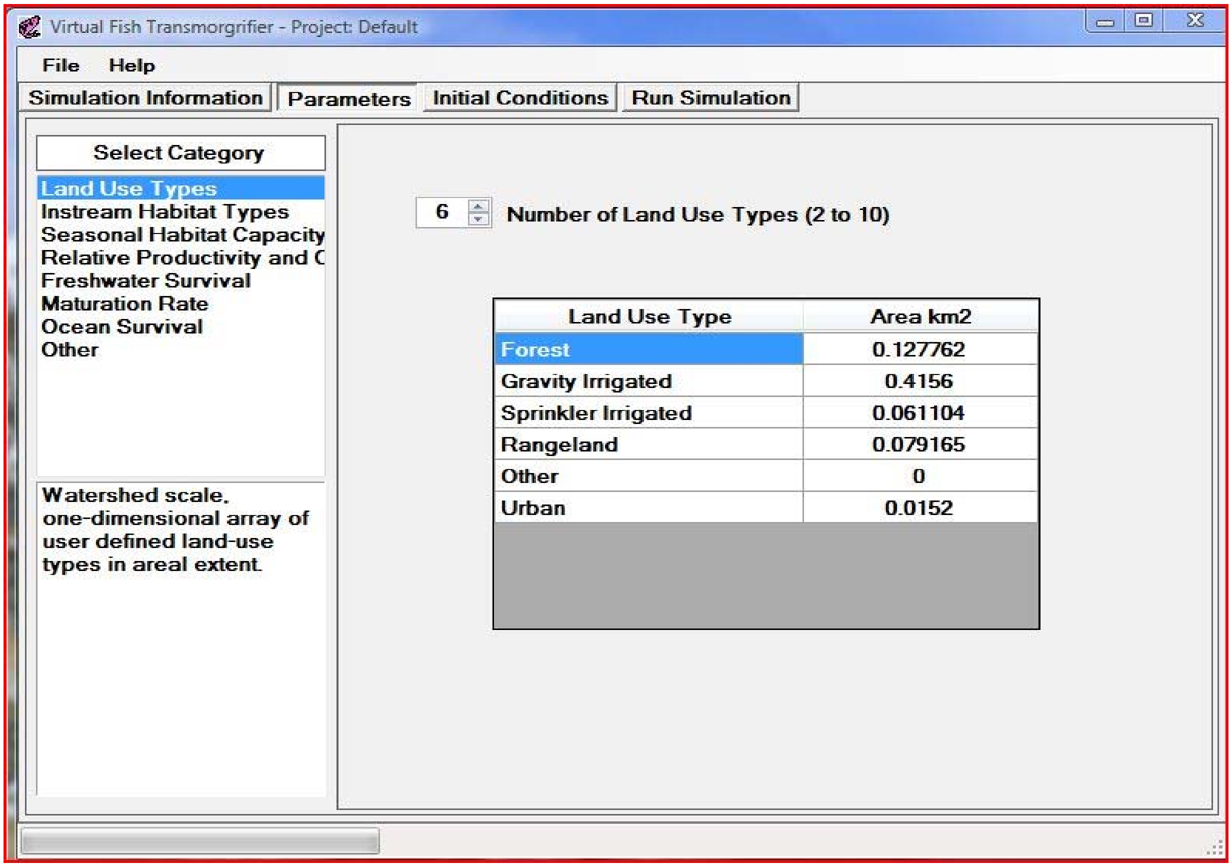
The date that the model was last modified (not editable)

Description

A description of the model (up to 65,000 characters)

Parameters

The parameters tab in the Program Interface is where most parameter estimates are input related to land-use types, instream habitat types, seasonal effects, and wild/hatchery population dynamics. Most windows and tables in the Program Interface are dynamic and can be adjusted to account for column headings, input data, , etc.



Land Use Types

One-dimensional array of the land-use types **area in km^2** located in the watershed of interest. Default land-use types are {Forest, Gravity Irrigated, Sprinkler Irrigated, Rangeland, Other, Urban}, however the user can define whatever type and number that is appropriate for the watershed of interest. The number of land-use types to enter is changed by using the up/down area at the top of the entry form, or by simply typing in the number of types desired. In order to enter data,   place the mouse cursor in the first cell in a row and enter the land-use heading desired. You can also use the Tab to toggle through the table's cells and rows. These values will be converted into m^2 in the simulation as other units assume m^2, not km^2.
The model supports from two to ten different land use types.
Example of default data using six land use types (km^2):

	Forest	Gravity Irrigated	Sprinkler Irrigated	Rangeland	Other	Urban
Value	0.127767	0.4156	0.061104	0.079165	0	0.0152

Instream Habitat Type Proportions

The instream habitat types are used to convert the land use type data into fish habitat types. This is done with an array of **proportions** that has a conversion factor for each land use type and its

corresponding habitat type. This array, therefore, will have a column for each land use type (user defined in Land Use Type Tab and cannot be changed in this screen) and a row for each habitat type (entry rules are the same as Land Use Type Tab). Default habitat types are {Pools, Cascades, Glides, Riffles, Runs, Other}. The user is responsible for determining the most appropriate habitat and or reach classification system that is sufficient for the data being modeled. Each land use type will be composed of some proportion of each of the habitat types, the sum of the habitat type proportions will sum to 1.0 for each land use.
The model supports from four to ten habitat types, within the constraints of the notes below.
Notes:

1. Changing the number of land use types will change the number of columns of the habitat proportions array. You may also change the number of habitat types, as long as the sum for each land use type is 1.0 (if a column does not add to 1.0, then it will be displayed in <u>red</u>)
2. The model will use the fourth habitat type as the designated spawning habitat (this is riffles in this set of habitat types).

Example of default data for six habitat types (proportions) and six land use types:

	Forest	Gravity Irrigated	Sprinkler Irrigated	Rangeland	Other	Urban
Pools	0.60	0.45	0.45	0.08	0.00	0.10
Cascades	0.00	0.00	0.00	0.00	0.00	0.00
Glides	0.06	0.10	0.06	0.24	0.00	0.09
Riffles	0.28	0.39	0.31	0.44	0.00	0.44
Runs	0.06	0.06	0.18	0.24	1.00	0.37
Other	0.00	0.00	0.00	0.00	0.00	0.00

Seasonal Habitat Capacity

This set of numbers represents the seasonal juvenile carrying capacity, or fish density, for the different habitat types defined in the previous parameter set. The user can enter fish density for each season and habitat type (**<u>units are in fish/m^2</u>**).
The model (version 1.0) currently supports three seasonal capacities, as listed below, and the seasonal change is relative between land use types. Future model versions will allow this to change, however this current version has fixed three seasons.
Example of default data (fish/m^2):

	Spring	Summer	Winter
Pools	2.275	1.55	0.7625
Cascades	0.00	0.20	0.00
Glides	1.80	0.08	0.10
Riffles	1.20	0.01	0.01
Runs	0.60	0.01	0.01
Other	1.80	1.05	0.50

Relative Productivity for Land Use

These scalars are used to adjust the instream habitat productivity of land-use types relative to the most productive habitat (e.g. 1.0). Land-use scalars are used to adjust life stage survival rates depending on the area the specific life-stage occupies during a specific time-period. Depending on the watershed of interest, none of the land-use types need to be 1.0. Only entry allowed on this screen are the productivity values and relative habitat changes..

Example of default data:

	Forest	Gravity Irrigated	Sprinkler Irrigated	Rangeland	Other	Urban
Value	1.00	0.70	0.70	0.65	0.50	0.50

This screen is also where the user can input <u>relative habitat changes</u> from flow between different seasons. The Relative Spring to Summer Habitat Change and Relative Spring to Winter Habitat Change describes the change in instream livable area because of seasonal flow changes, depending on the watershed's discharge characteristics.

Freshwater Survival – Natural

This is defined as the average maximum average survival rate (**<u>units: 100% = 1.00</u>**) for naturally produced fish from one stage to the next in the fresh-water life history of the species given average conditions compared to a baseline in the best possible habitat suited for their survival.

Note:

1. All parameters that are a function of life stages must use the five-year life stage model as specified in the input screen and only the survival can be changed.

Example of default data:

	Egg to Fry	Fry to Parr	Parr to Pre-Smolt	Pre-Smolt to Smolt	Smolt to Adult
Value	0.16	0.30	0.50	0.90	1.00

Freshwater Survival – Hatchery

Hatchery survival rates are defined similar to natural fish survival, but for fish living in the hatchery. The same life stages apply as natural fish.

Example of default data:

	Egg to Fry	Fry to Parr	Parr to Pre-Smolt	Pre-Smolt to Smolt	Smolt to Adult
Value	0.75	0.75	0.75	0.75	0.75

Maturation Rate

VFT version 1.0 is set up for stream-type Chinook salmon. Maturity rates are defined as the percent of fish by age that mature in the ocean and migrate to their natal streams (**<u>units: 90% = 0.90</u>**). The oldest age fish maturity rate must be 1.00, by definition. The user can only change the maturation rates in this screen.

Example of default data:

	Age-2	Age-3	Age-4	Age-5
Value	0.00	0.15	0.40	1.00

Ocean Survival Rate

VFT version 1.0 is set up for stream-type Chinook salmon. Ocean survival is by age (**units: 90% = 0.90**). The user can only change the ocean survival rates in this screen.
Example of default data:

	Age-2	Age-3	Age-4	Age-5
Value	0.00	0.03	0.80	0.90

Other Model Parameters

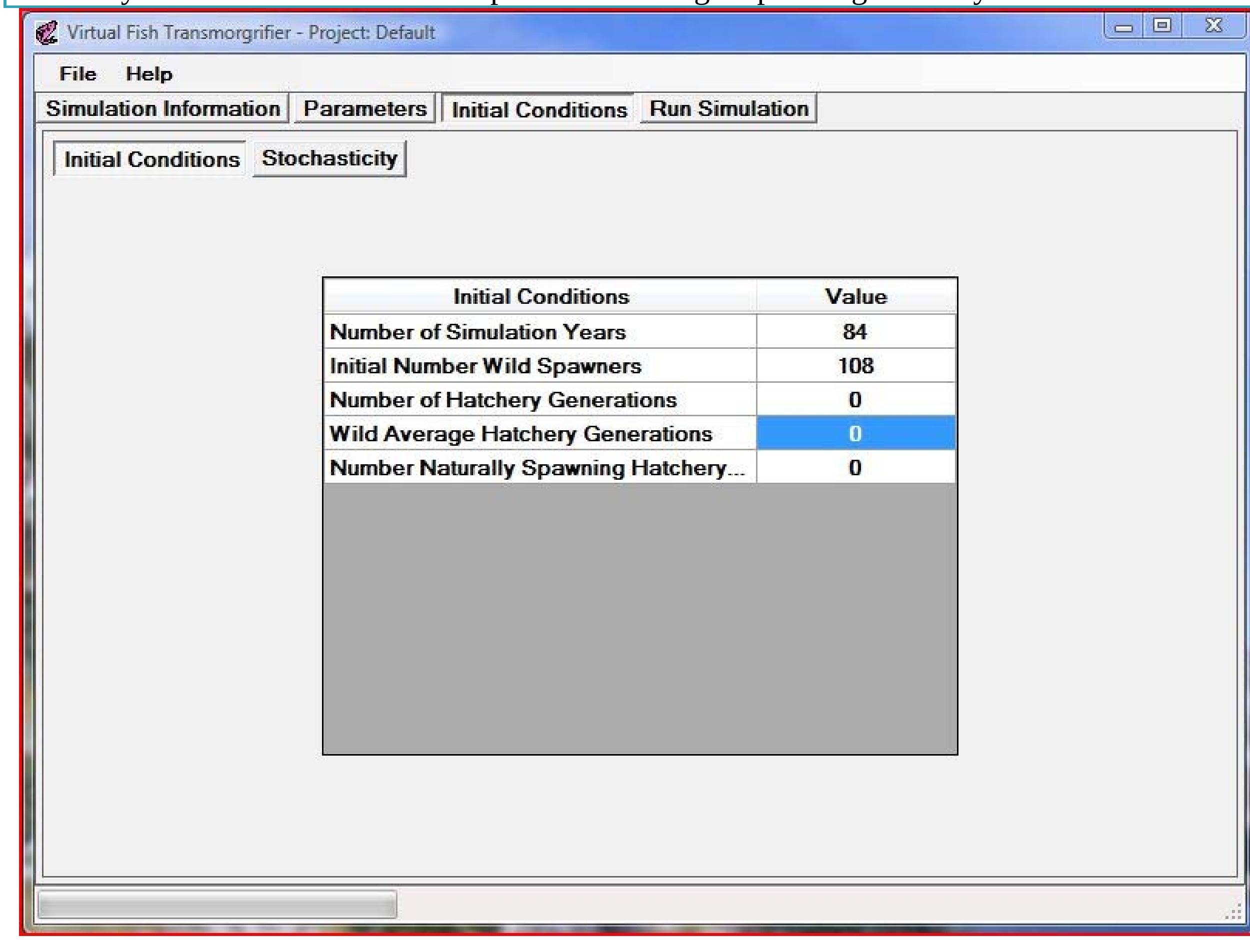
These parameters describe wild and hatchery terminal harvest rates, the watersheds spawner carrying capacity, and wild and hatchery average female fecundity. The user can only change the values in this screen.

Input Variable	Description	Value
Hatchery Smolts/Spawner	The number of smolts produced by each hatchery female	2000
Hatchery Smolt to Adult Survival	Survival of hatchery smolts to terminal area	0.035
Hatchery Stray Rate	Stray rate of hatchery fish spawning with natural fish (percent of escapement, in decimal form)	0.30
Wild Stray Rate	Stray rate of wild fish out of watershed (percent of escapement, in decimal form)	0
Hatchery Harvest Rate	Number of hatchery fish removed for all terminal fisheries combined (percent of terminal run, in decimal form)	0.10
Wild Harvest Rate	Number of natural fish removed for all terminal fisheries combined (percent of terminal run, in decimal form)	0.10
Spawner Carrying Capacity	The watershed’s theoretical capacity for numbers of spawning fish	833
Average Fecundity	Average number of eggs produced by wild females	1750

Initial Conditions

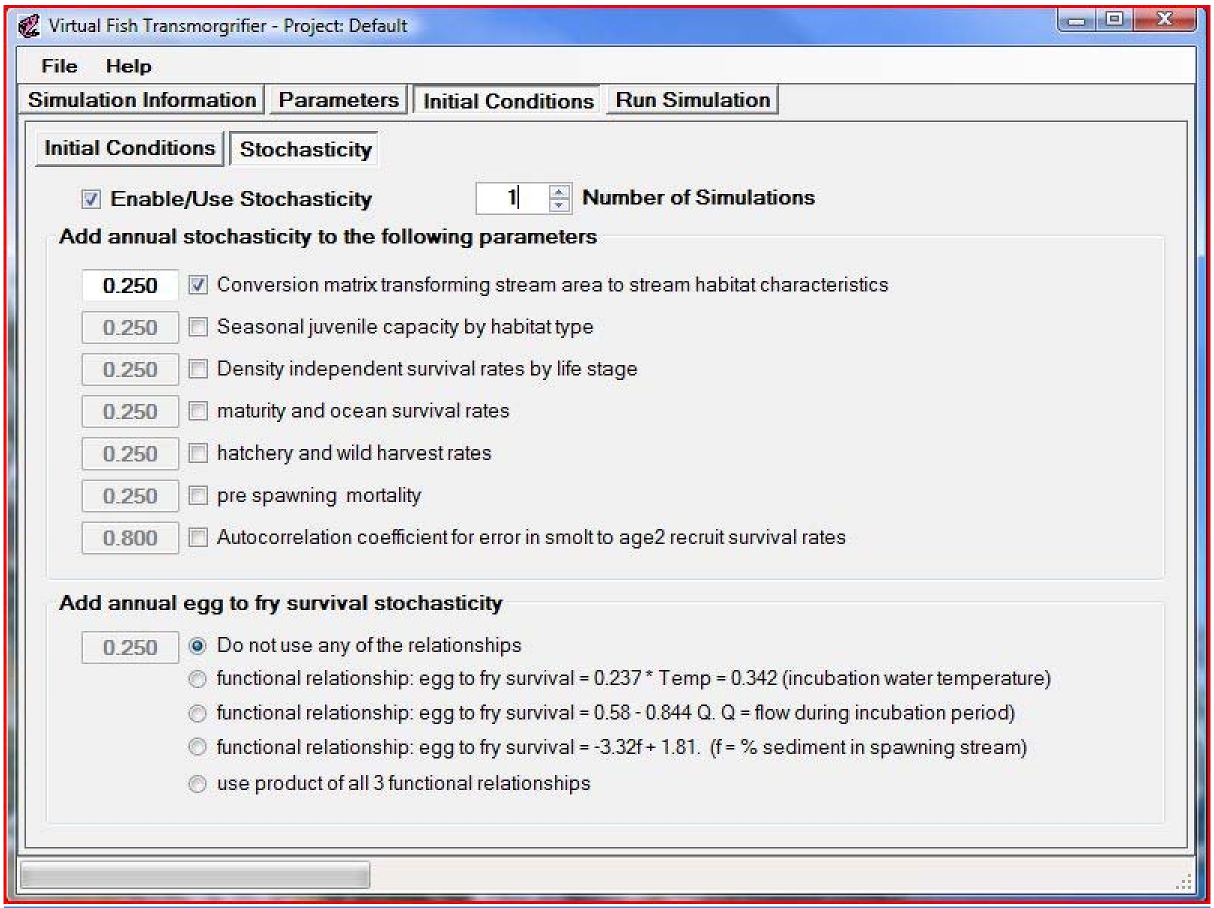
Initial Conditions Tab sets up the duration of the simulation, the starting hatchery influence both for the natural fish and in the hatchery, and the starting number of fish to seed the model. If no hatchery fish exist in the system enter 0 for Hatchery Spawners, if there is no known historical hatchery influence enter zero for Wild Average Hatchery Generations.

Input Variable	Description	Value
Number of Simulation Years	Determines the number of years to run the simulation	84
Initial Number of Wild Spawners	Initial seed value for the number of natural spawners of all ages	108
Number of Hatchery Generations	Number of years the hatchery stock has been domesticated	0
Wild Average Hatchery Generations	Average number of hatchery generations spawning with natural fish	0
Number of Naturally Spawning Hatchery Fish	Initial seed value for the number of hatchery spawners of all ages spawning naturally	0



Adding Stochasticity

Adding uncertainty or variance to simulations provides an understanding of the volatility of the output as different sets of parameters and input conditions change. To see Stochasticity Page details, choose the Stochasticity Button and select Enable/Use Stochasticity. The VFT provides the ability to selectively add stochasticity to sets of data, and then run the model for multiple runs to study the output envelope. The model uses a Coefficient of Variation (CV) for this function. CV represents the ratio of the standard deviation to the mean and represents the dispersion of data points in a data series. A normal distribution function generates the random deviates depending on the CV entered for a parameter.
The number of simulations value will control the number of complete simulations for the number of years indicated. This will result in N values being calculated for each year, where N is the number of simulations. The uncertainty in the parameter types of interest are determined by the value of CV. The user can choose one or many.



Coefficient of Variation for Parameters

The model adds uncertainty to each of the following data types from a user chosen value (CV = 0.25 is the default value):

Parameter Sets	Description	Value

Parameter Sets	Description	Value
Instream Habitat Type Proportions	Uncertainty added to habitat proportions	0.25
Seasonal Habitat Capacity	Uncertainty added to juvenile densities	0.25
Freshwater survival	Uncertainty added to freshwater life stage survival	0.25
Maturity and ocean survival rates	Uncertainty added to both maturity and ocean age specific rates	0.25
Hatchery and wild harvest rates	Uncertainty in terminal harvest rates	0.25
Pre-spawning mortality	Uncertainty in natal stream pre-spawn mortality	0.25
Autocorrelation coefficient smolt to age 2 recruit survival rates	If the user is interested in apply uncertainty to the yearly correlated survival between smolts and age 2 recruits in the ocean	0.80

Egg to Fry survival

Additional uncertainty can be studied by adding one or all of the following functional relationships that allows the egg to fry survival be modeled given uncertainty in climatic conditions and allowing stochasticity in one of four ways:

1. Egg to Fry survival = 0.237 * Temp = 0.342 (variance added to incubation water temperature)
2. Egg to Fry Survival = 0.58 – 0.844 Q (variance added to Q = flow during incubation period)
3. Egg to Fry Survival = -3.321 f + 1.81 (variance added to f = is the percent of sediment in spawning areas)
4. Use the product of all three.

Projects and Organizing Data

The VFT model software provides a way to manage nearly unlimited number of projects, where a project is defined as a simulation with its defining parameters and other conditions. Each project is defined by the following:

- A unique name (up to 255 characters in length – not editable)
- The date that the model was last modified (not editable)
- A description of the model (up to 65,000 characters), and
- A set of data files (parameters, etc.)

Each project or simulation is defined by a folder which contains all files associated with that project. The details of this will be explained in the following sections. Directly changing files within a project folder may cause a logic corruption that will render the project in-operable. Caution must be used in accessing and or changing project files.

Folders and Projects

The root folder for all projects is “My Documents\VFT”. The root location cannot be changed in version 1.0. There is always a default project and default project folder, “My Documents\VFT\default”. If this folder is deleted, it will be re-created the next time the VFT model is run.

When a new project is made, a new folder with the project name will be created in the VFT folder with a default set of files. As the parameters and changes to other data area made, and the simulation is executed, additional files and changes to existing files will be made.

Data Backup

Keeping a backup copy of important data is a must and is left as an exercise for the student. Making a copy of the VFT folder and all sub-folders to a CD-Writer or other durable storage on a regular basis should become part of your work process.

The PAIN data backup strategy works best: how much pain will it be to lose the work that you just did since your last backup copy?

Project Files

The following is a list of project files and their contents:

File Name	Description
Info.csv	Basic information about the project: date last modified and user description
Model.csv	Contains the initial conditions for the simulation.
Output.csv	After the simulation is run, this contains a table of all the results for each year of the simulation, and for all the simulation passes.
Parameters.csv	Contains all the project parameters for the simulation.
Stochasiticity.csv	Contains the uncertainty variables for the model.

Run Simulation (Output)

When the simulation button [RUN] is clicked, the output flows to several locations:

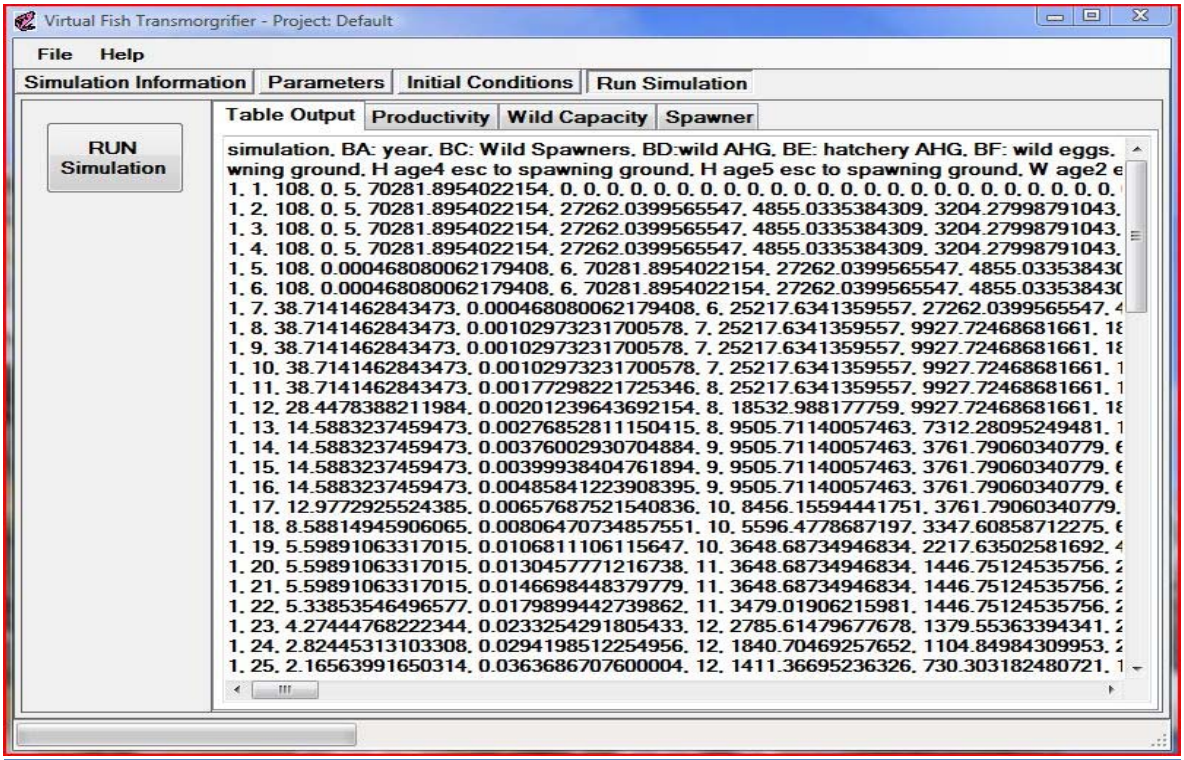
1. To the text box on the Table Output tab of the Run Simulation section.
2. To the output.csv file in the project folder (duplicates the Table Output tab).
3. To the Productivity, Wild Capacity, and Spawner graphs.

    Note: each graph is updated with the current model run and they are used to quickly observe the output data over the length in years simulated.

4. To a variety of intermediate files (“trace”) in the project folder, if running a “stochastic” simulation. Only the variables that have uncertainty added to them will be written to the trace files, however, empty trace files will always be written with one exception (see 4a). These files save detailed information for each parameter that has stochasticity added by the user and the influenced intermediate data carried by the program. For example, if the user chooses to have uncertainty added to “juvenile capacity by habitat type”, two trace files will be written: 1) Capacity_Productivity.csv and 2) habitatProportion.csv,

because both trace files will have data that changes from the initial parameter values entered by the user, adjusted according to the uncertainty (CV).

a. **[One Exception]** The trace file Capacity_Productivity.csv will always have data written to it. This provides the user with the intermediate data for a watershed by season, instream habitat adjusted to square meters, and the resultant seasonal capacity, and life-stage productivity.


Virtual Fish Transmorgrifier - Project: Default
File Help
Simulation Information
Parameters
Initial Conditions
Run Simulation
RUN Simulation
Table Output
Productivity
Wild Capacity
Spawner
simulation. BA: year. BC: Wild Spawners. BD:wild AHG. BE: hatchery AHG. BF: wild eggs.
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1. 1. 108. 0. 5. 70281.8954022154. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.
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Virtual Fish Transmorgrifier - Project: Default
File Help
Simulation Information
Parameters
Initial Conditions
Run Simulation
RUN Simulation
Table Output
Productivity
Wild Capacity
Spawner
70000
60000
50000
40000
30000
20000
10000
0

Output.csv File

The simulation outputs all data for each year of each simulation into the specified output file.

Column	Column Label	Description
A	simulation	Will always = 1 if not using the stochastic function
B	year	Starts at year 1 to user entered maximum value
C	Wild Spawners	Total number of wild spawners returning to watershed
D	wild AHG	Average number of hatchery generations spawning with natural fish
E	hatchery AHG	Average number of generations that a hatchery's broodstock has been domesticated
F	wild eggs	Number of eggs produced by naturally spawning females
G	emergent fry	Number of fry in spring after emergence
H	summer parr	Number of summer parr
I	wild smolts	Number of smolt that migrate from watershed
J	hatchery smolts	Number of smolts released by hatchery into watershed
K	Wild age2 ocean cohort	Total number of wild fish in the ocean at age 2
L	Wild age3 ocean cohort	Total number of wild fish in the ocean at age 3
M	Wild age4 ocean cohort	Total number of wild fish in the ocean at age 4
N	Wild age5 ocean cohort	Total number of wild fish in the ocean at age 5
O	Hatchery age2 ocean cohort	Total number of hatchery fish in the ocean at age 2
P	Hatchery age3 ocean cohort	Total number of hatchery fish in the ocean at age 3
Q	Hatchery age4 ocean cohort	Total number of hatchery fish in the ocean at age 4
R	Hatchery age5 ocean cohort	Total number of hatchery fish in the ocean at age 5
S	Wild termRun age2	Wild terminal run age 2
T	W termRun age3	Wild terminal run age 3
U	W termRun age4	Wild terminal run age 4
V	W termRun age5	Wild terminal run age 5
W	H termRun age2	Hatchery terminal run age 2
X	H termRun age3	Hatchery terminal run age 3
Y	H termRun age4	Hatchery terminal run age 4
Z	H termRun age5	Hatchery terminal run age 5
AA	W imm age2	Wild cohort remain in ocean after maturation
AB	W imm age3	Wild cohort remain in ocean after maturation
AC	W imm age4	Wild cohort remain in ocean after maturation
AD	H imm age2	Hatchery cohort remain in ocean after maturation
AE	H imm age3	Hatchery cohort remain in ocean after maturation
AF	H imm age4	Hatchery cohort remain in ocean after maturation
AG	W termCatch age2	Wild fish caught in all terminal fisheries Age 2
AH	W termCatch age3	Wild fish caught in all terminal fisheries Age 3
AI	W termCatch age4	Wild fish caught in all terminal fisheries Age 4

AJ	W termCatch age5	Wild fish caught in all terminal fisheries Age 5
AK	H termCatch age2	Hatchery fish caught in all terminal fisheries Age 2
AL	H termCatch age3	Hatchery fish caught in all terminal fisheries Age 3
AM	H termCatch age4	Hatchery fish caught in all terminal fisheries Age 4
AN	H termCatch age5	Hatchery fish caught in all terminal fisheries Age 5
AO	W termEsc age2	Wild age 2 fish escaping fisheries into watershed
AP	W termEsc age3	Wild age 3 fish escaping fisheries into watershed
AQ	W termEsc age4	Wild age 4 fish escaping fisheries into watershed
AR	W termEsc age5	Wild age 5 fish escaping fisheries into watershed
AS	H termEsc age2	Hatchery age 2 fish escaping fisheries into watershed
AT	H termEsc age3	Hatchery age 3 fish escaping fisheries into watershed
AU	H termEsc age4	Hatchery age 4 fish escaping fisheries into watershed
AV	H termEsc age5	Hatchery age 5 fish escaping fisheries into watershed
AW	W age2 esc to natal stream	Wild age 2 fish escaping into watershed and not used for hatchery brood stock
AX	W age3 esc to natal stream	Wild age 3 fish escaping into watershed and not used for hatchery brood stock
AY	W age4 esc to natal stream	Wild age 4 fish escaping into watershed and not used for hatchery brood stock
AZ	W age5 esc to natal stream	Wild age 5 fish escaping into watershed and not used for hatchery brood stock
BA	H age2 esc to spawning ground	Hatchery age 2 fish escaping into watershed and not used for hatchery brood stock but allowed to spawn naturally
BB	H age3 esc to spawning ground	Hatchery age 3 fish escaping into watershed and not used for hatchery brood stock but allowed to spawn naturally
BC	H age4 esc to spawning ground	Hatchery age 4 fish escaping into watershed and not used for hatchery brood stock but allowed to spawn naturally
BD	H age5 esc to spawning ground	Hatchery age 5 fish escaping into watershed and not used for hatchery brood stock but allowed to spawn naturally
BE	W age2 esc to hatchery	Wild age 2 fish used for hatchery broodstock
BF	W age3 esc to hatchery	Wild age 3 fish used for hatchery broodstock
BG	W age4 esc to hatchery	Wild age 4 fish used for hatchery broodstock
BH	W age5 esc to hatchery	Wild age 5 fish used for hatchery broodstock
BI	H age2 esc to hatchery	Hatchery age 2 fish used for hatchery broodstock
BJ	H age3 esc to hatchery	Hatchery age 3 fish used for hatchery broodstock
BK	H age4 esc to hatchery	Hatchery age 4 fish used for hatchery broodstock

BL	H age5 esc to hatchery	Hatchery age 5 fish used for hatchery broodstock
BM	total age4&5	Total wild age 4 and age 5 escapement to natal stream.

trace*.csv Files

File Name	Description
AutoCorrelatedError.csv	This trace file will have the normal deviates used for each run, the relationship between smolts and age 2 fish, the autocorrelated error, and resultant Hatchery and/or hatchery smolt coefficients
Capacity_Productivity.csv	This trace file will always have data written to it. It stores the parameter estimates for the amount of a watershed's instream habitat area by type and season, and the resulting life-stage specific capacity and productivity by year and simulation
CapacityPerArea.csv	This trace file stores the juvenile capacity parameter values for each instream habitat type by season, year and simulation
eggToFrySurvRate.csv	Stores the coefficients (flow, sediment, and/or temperature) by year and simulation from the functional relationships chosen by the user in stochasticity input screen
habitatProportion.csv	Stores the proportion of habitat by each instream habitat type, land-use type, year and simulation
harvestRate.csv	Stores the harvest rate for Hatchery and hatchery fish by year and simulation
maturityRate.csv	Stores the age specific maturation rates by year, and simulation
survRate.csv	Stores the live stage specific survivals by life stage, year, and simulation